NORTHERN ARIZONA UNIVERSITY

Material Testing Fixture

April 26, 2013

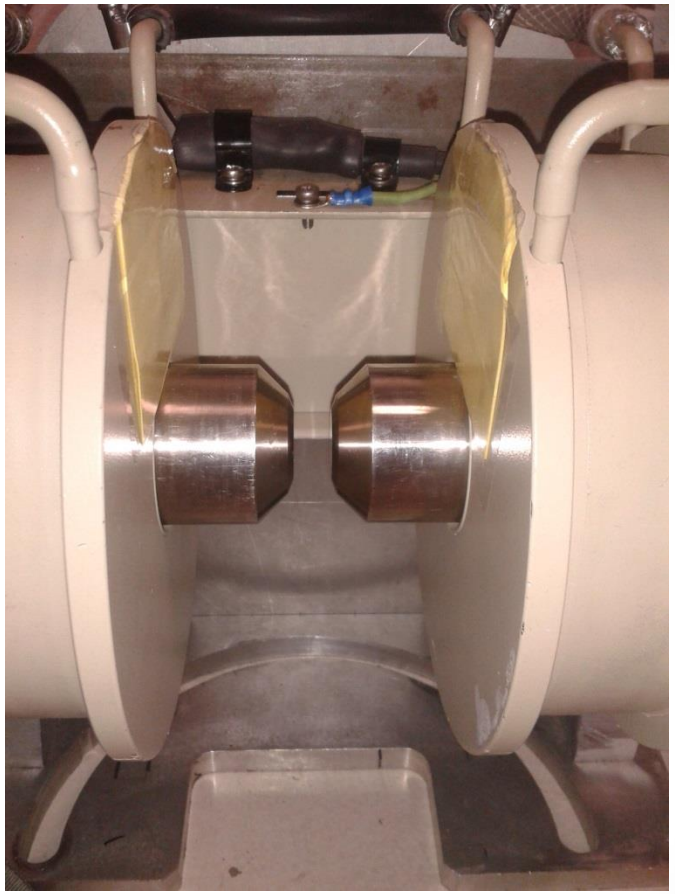
Matt Garcia, Randy Jackson,
Jeremy Mountain, Qian Tong, Hui Yao

Sponsor: Dr. Cornel Ciocanel

College of Engineering, Forestry and Natural Sciences
Northern Arizona University

Overview

1. Project Introduction
2. Current Fixture
3. Our Solution Design
4. Prototyping
5. Material Selection
6. Analysis
7. Manufacturing
8. Final Product
9. Budget



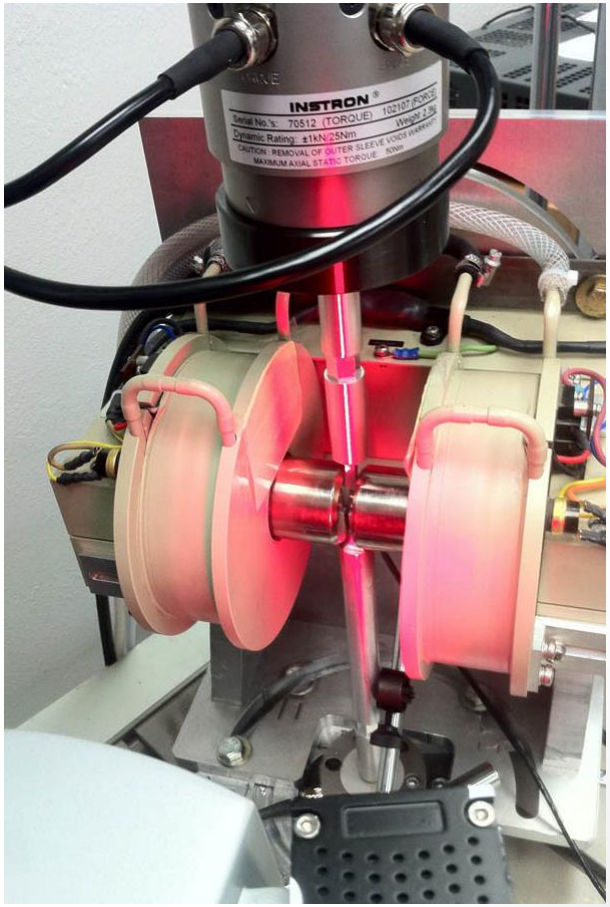
Project Introduction

Magnetic Shape Memory Alloys (MSMA's)

- Nickel-Manganese-Gallium
- Magnetic Elongation of 6%
- $1,000/specimen

Unknown Material Properties

- Mathematically Model
- Actuators
- Switches



Matt Garcia

Problem Statement

Need: The eccentric loading of the test specimens causes fatigue failure.

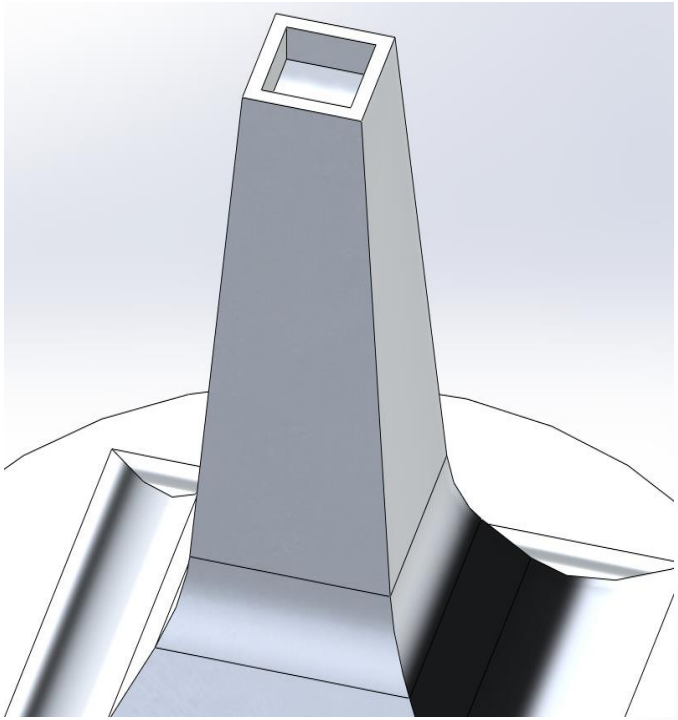
Goal: Design an improved material testing fixture that can perform tension and compression tests.

Constraints

1. Fixture must accommodate specimen – 3 x 3 x 20 [mm]
2. Fixture must perform tension and compression tests
3. Exposed length of specimen – 10 [mm]
4. Fixture must not damage specimen
5. Fixture must be non-magnetic
5. Distance between magnets – 10 [mm]
6. Fixture must be axially aligned – 50 [µm]

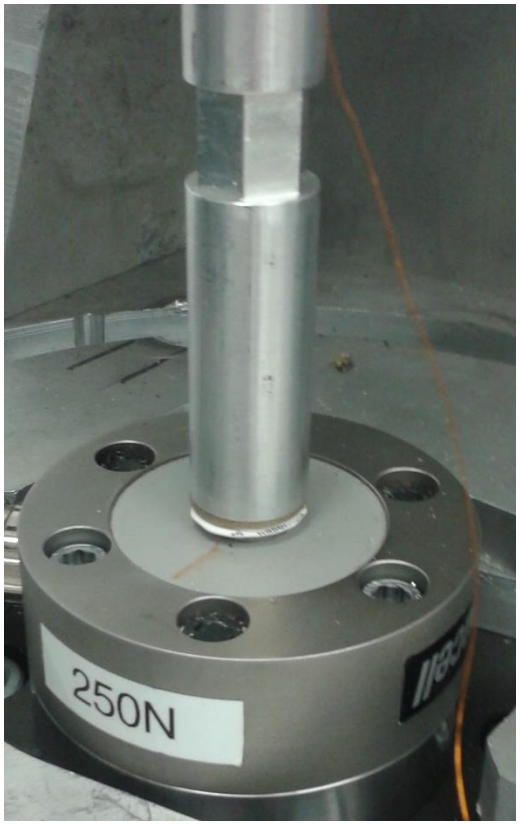
Current Fixture– Tip

- Eccentric loading
- Only compression test capable
- Poor tolerances



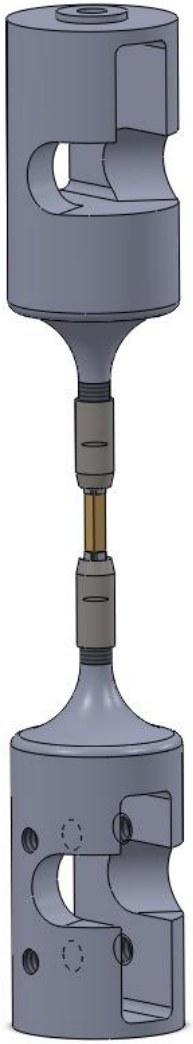
Current Fixture – Base

- Screw for alignment
- Instability due to length of rod
- Small diameter
- Requires spacers for alignment



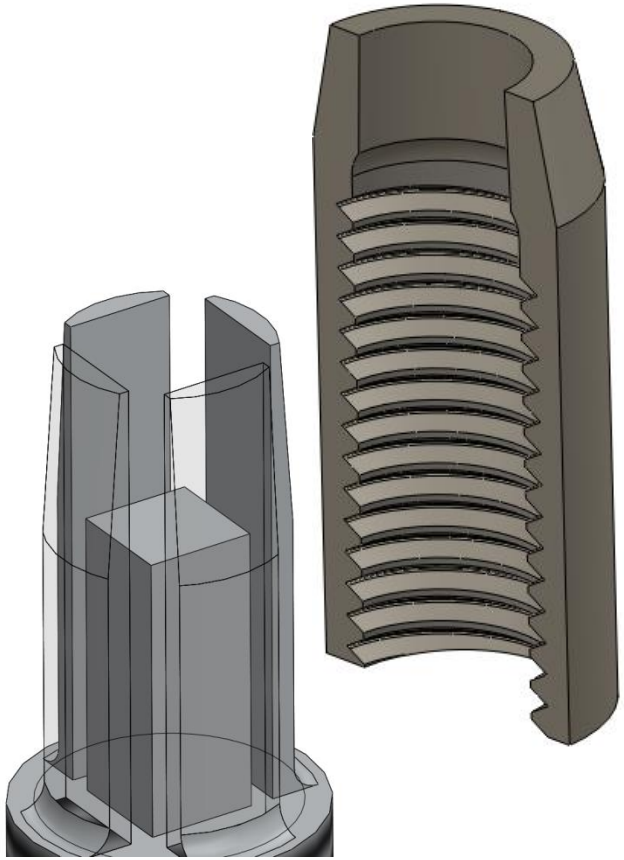
Our Solution

- Collet Tip / Sleeve
- Upper Push Rod
- Lower Push Rod
- Washer



Jeremy Mountain

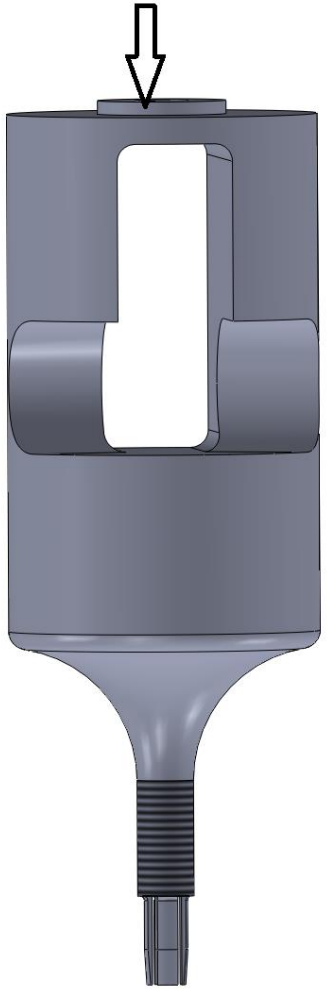
Solution Design – Tip / Sleeve



- Tension – Tines
- Axially aligns specimen
- Variable specimen size
- Compression - Post

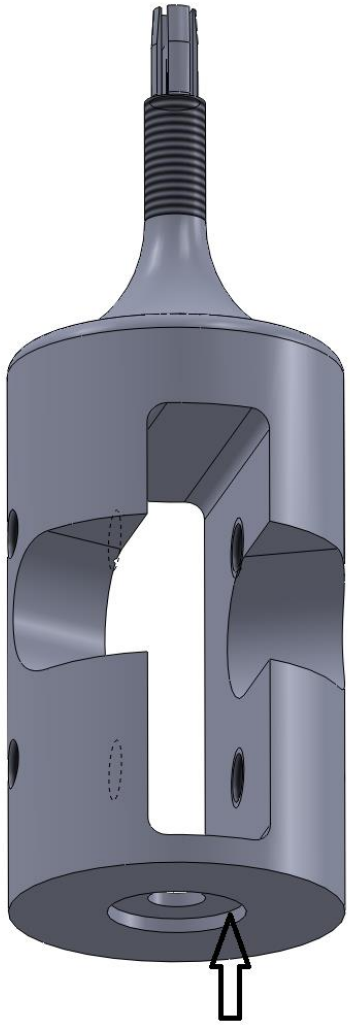
Jeremy Mountain

Solution Design – Upper



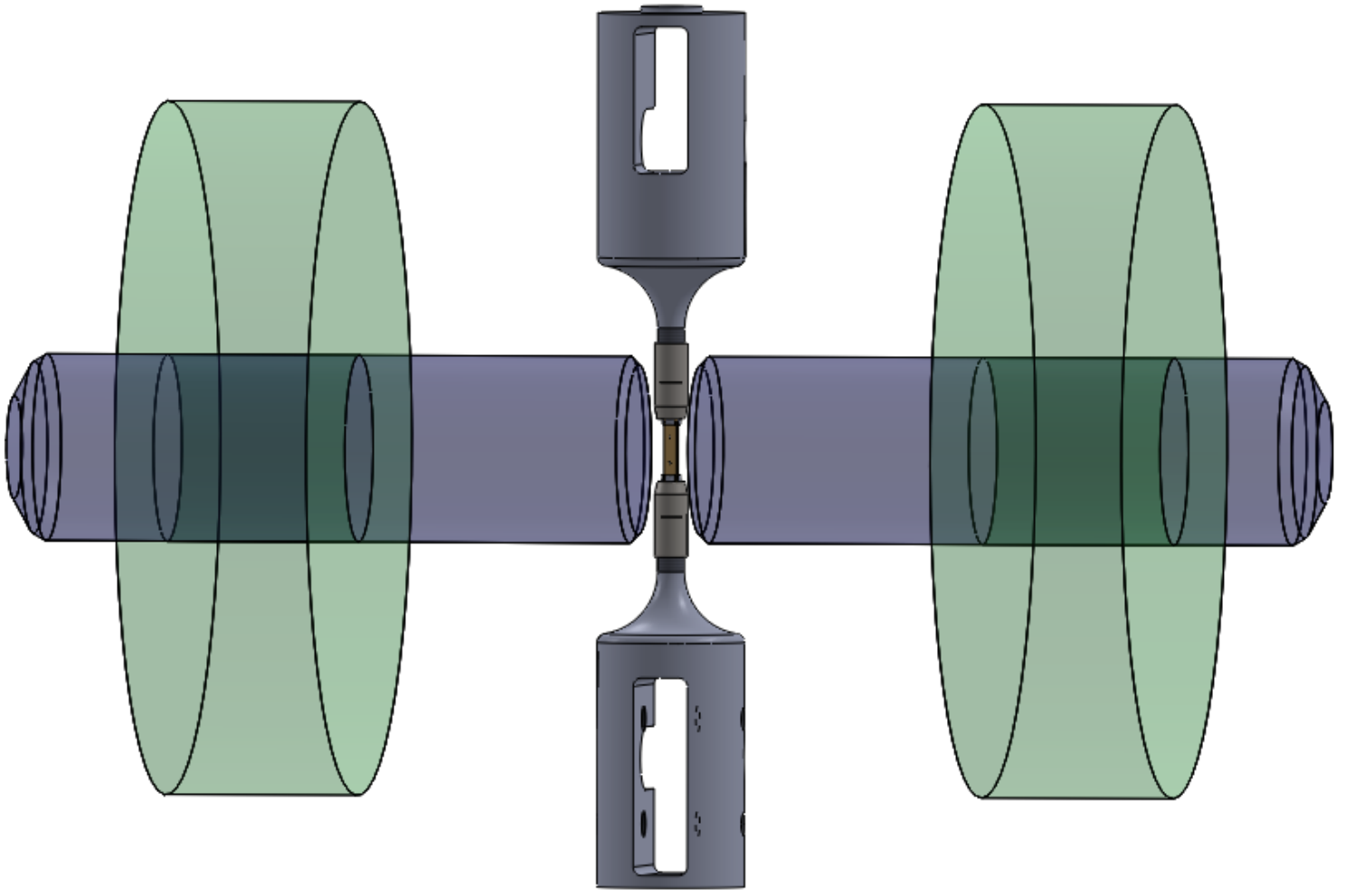
- Extruded cylinder for alignment
- Reduced overall height
- Tightening slot

Solution Design – Lower



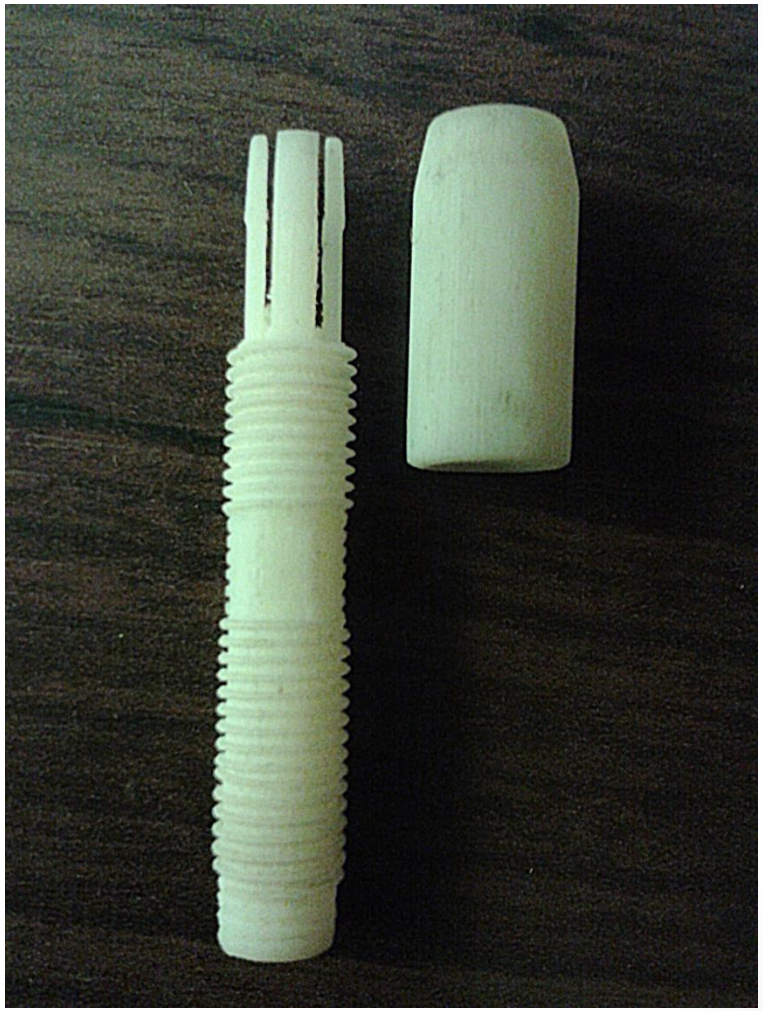
- Cylinder cutout for alignment
- Reduced overall height
- Tightening slot
- Micrometer slot

Solution Design – Assembly



Prototyping

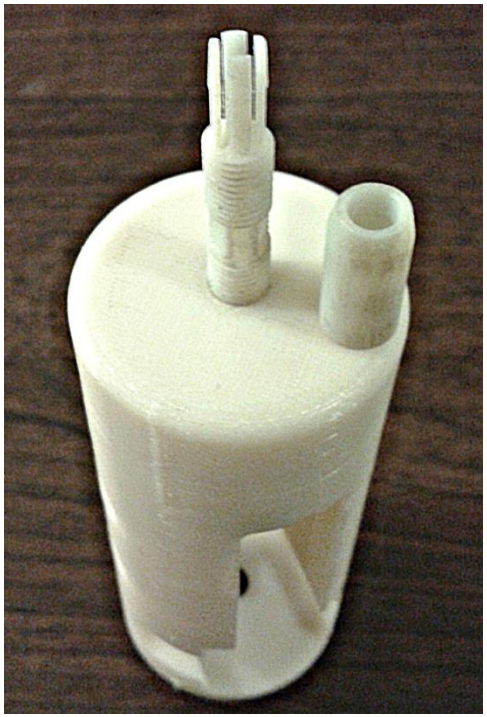
- Tip
- Sleeve
- Taper for tightening

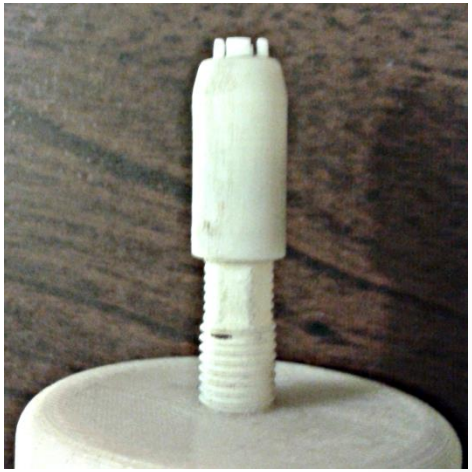


Qian Tong

Prototyping – Cont.

- Lower push rod
- Assembled





Prototyping – Cont.

- Proof of concept
- Tension & compression

Material Selection

Available Materials

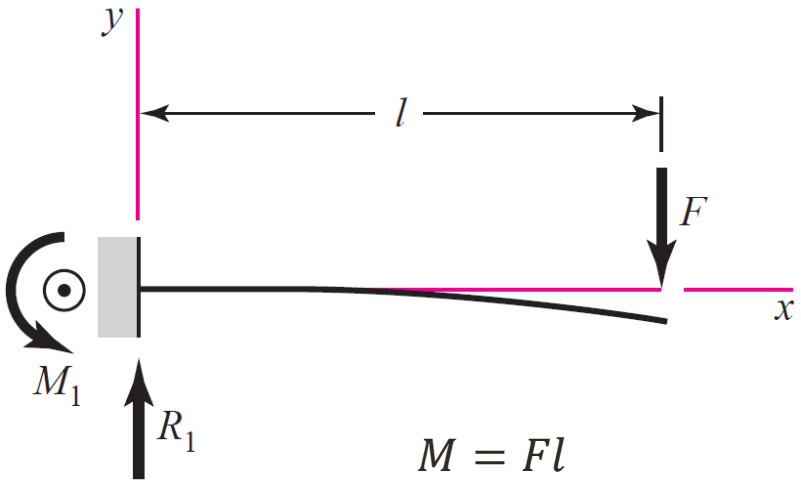
1. Stainless Steel 316
2. Aluminum 7075 – T6
3. Aluminum 6061 – T6
4. Brass

Final Design

- Aluminum 7075 – T6
- Hardness
- Non-magnetic properties
- Machinability

Analysis – Hand Calculations

- Cantilever beam analysis
- Alum. 7075 –T6 material properties



$$M = Fl$$

$$\delta_{max} = -\frac{Fl^3}{3EI}$$

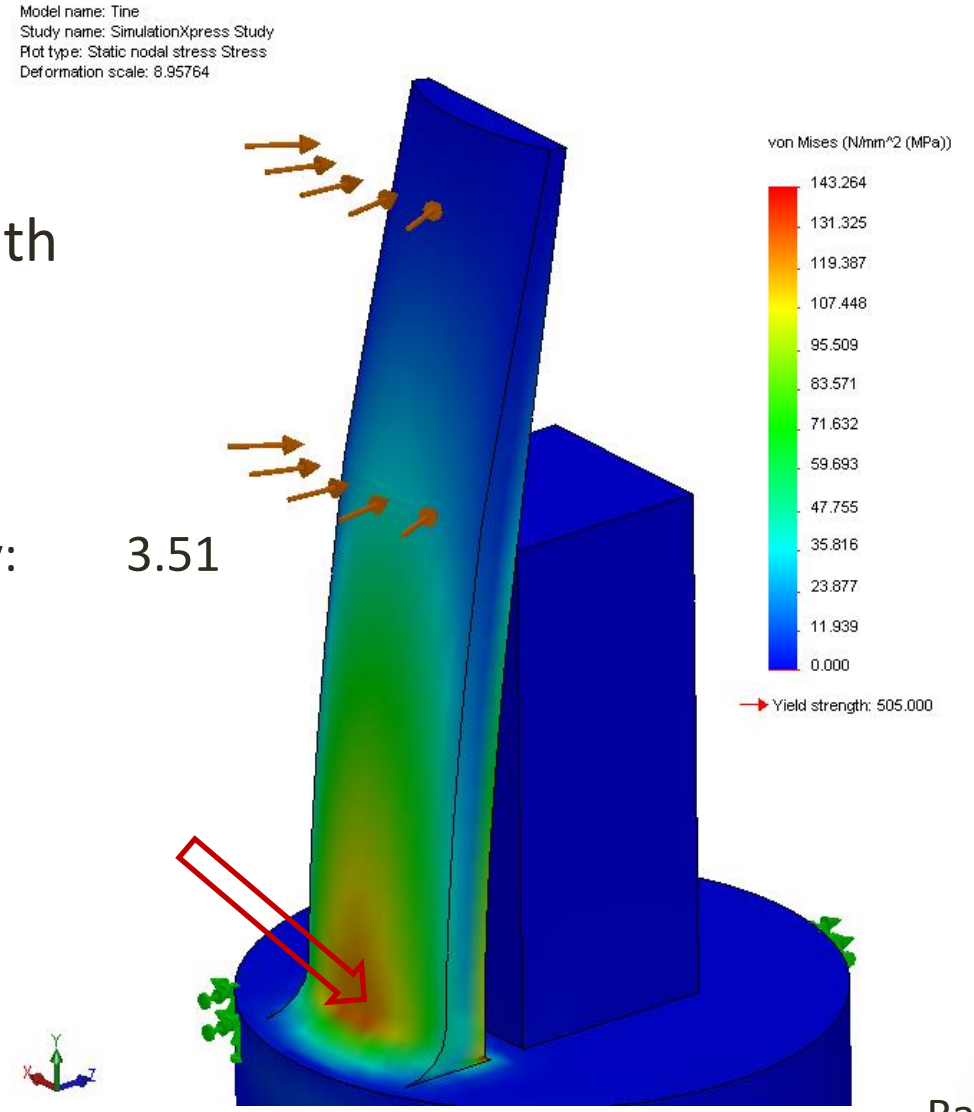
Factor of Safety: 3.98

$$\sigma = \frac{Mc}{I}$$

Analysis – SolidWorks

- Confirmed with SolidWorks

Factor of Safety: 3.51

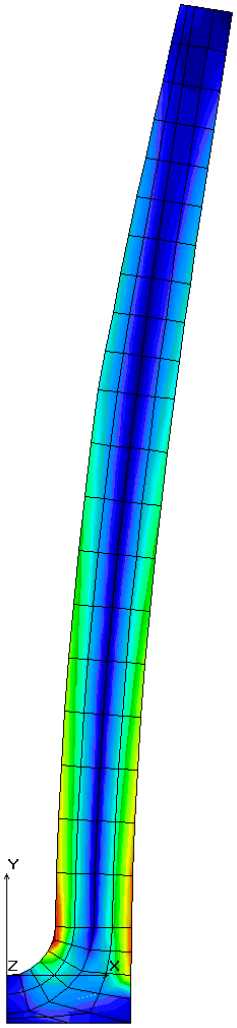


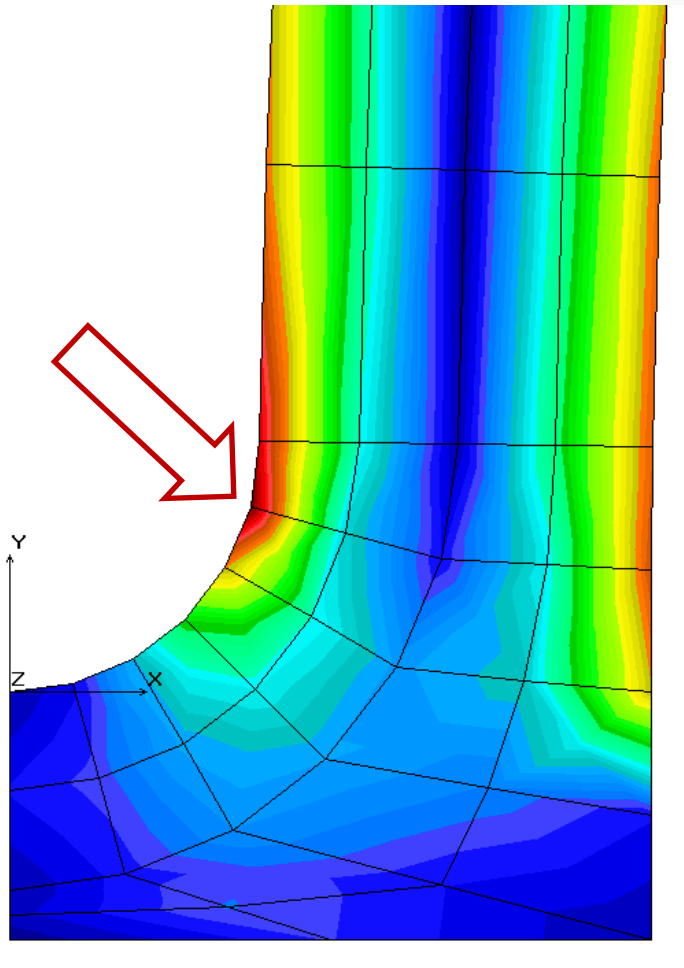
Randy Jackson

Analysis – COSMOS/M

- Confirmed with COSMOS/M

Factor of Safety: 3.53





Randy Jackson

Manufacturing

- Tolerances are critical

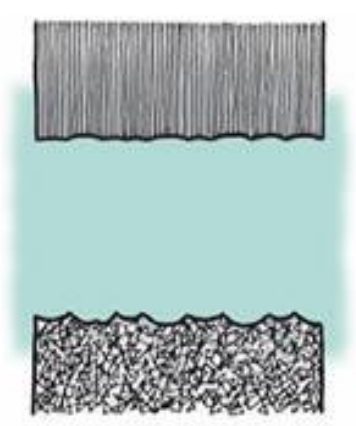
Machining Options

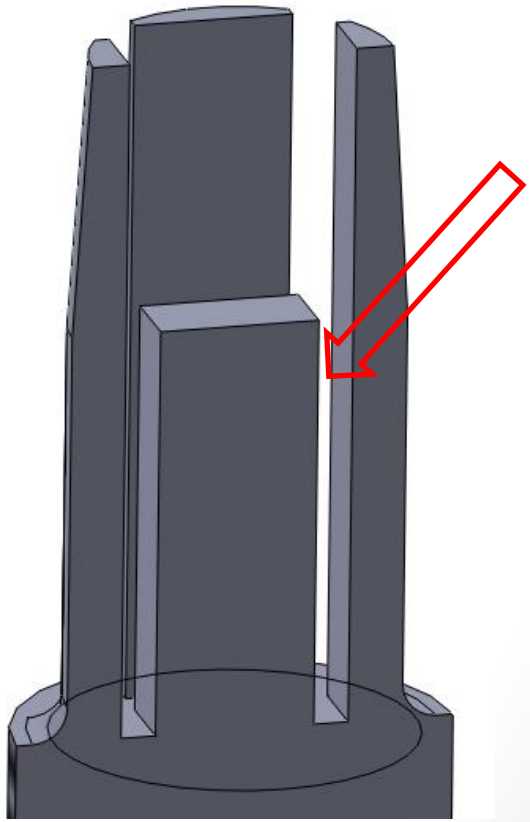
- NAU Machine Shop
- Elrod Machine & Manufacturing Inc.
- David Barnes Company

Hui Yao

Manufacturing – Cont.

- Small scale causes difficulty in manufacturing
- Tolerances are critical
- EDM – Electro Discharge Machining





Hui Yao

Final Product

- Silicon sleeve built into design

Hui Yao

Final Product – Cont.

Problem

- Incorrect outer diameter

Solution

- Pressure fit brass washer

Hui Yao

Final Assembly

- Achieved axial alignment
- No damage to specimen
- Tension & compression capable
- Simplified design

Hui Yao

Budget

- Loose budget limits due to research

- Theoretical

  Prototyping: $700 USD

  Machining: $3,000 - $5,000 USD

Total Cost: $6,000 USD

Conclusion

1. Identify Problems & Needs – Eccentric loading
2. Define Constraints : Axial alignment / magnet distance
3. Concept Generation – Design stage iterations
4. Final Design Selection – Collet tip style design
5. Analysis – Safety factor against yielding
6. Prototyping – 3D printing: push rod / sleeve / tip
7. Manufacturers Drawings – GD & T
8. Manufacturing – Mark Plourde @ David Barnes Company
9. Final Modifications – Press fit washer
10. Presented Final Product

Randy Jackson

References

http://www.davidbarnescompany.com

http://www.goodfellow.com

http://www.engineershandbook.com/Tables/frictioncoefficients.htm

http://www.engineersedge.com

http://www.alibaba.com

http://www.tcdcinc.com

http://www.engineeringtoolbox.com/friction-coefficients-d_778.html

http://www.youtube.com/watch?v=sPwURRG9_Gs

http://nau.edu/Research/Feature-Stories/NAU-on-Leading-Edge-of-Smart-Materials-Research/

Shigley's Mechanical Engineering Design, 9th Edition.

Mark Plourde – David Barnes Company

Dr. Cornel Ciocanel